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VOLUME VIII—No. 5
MAY, 1943

32 VICTORIA ST
LONDON, SW1

SESSION 1942–1943

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LIGHTING IN THE COTTON INDUSTRY

By J. W. HOWELL, D.L.C., M.I.E.E. *(Fellow)*

(Paper read before the Manchester Centre (North Western Area) on January 14th, 1943, and at the Sessional Meeting in London on March 9th, 1943).

Introduction

The Cotton industry, which is mainly concentrated in the Lancashire area, has been notorious for many years for its extremely bad lighting, which can be attributed to several causes, not the least of which has been finance. The importance of Textiles can be realised if it is remembered that in normal times approximately 1,000,000 operatives are employed, the majority being engaged in cotton processes. As one of the oldest industries its development in the lighting field has been particularly difficult. Nowhere has the objection of the manufacturer to any increased manufacturing costs or the opposition of operatives to any innovation which might lower piece rates been more pronounced. Thus to-day the atmosphere in many mills is extremely depressing and the lighting unworthy of such an important industry. Old-fashioned electric and gas installations are still prevalent in certain sections of weaving.

The industry is concerned with a base of vegetable fibre instead of animal fibre, as in the case of woollens, which involves questions of humidity to ensure elasticity in the cotton and better control of the fibre under process. Processes, though resembling those in other textiles, are known by different names and performed by entirely different machines. Cotton, whether it be weft or twist, is an entirely different proposition from the much coarser and hairy woollen thread, different speeds of operation being also involved. In consequence the visual task involved may be less exacting, and lower values of illumination may be used for processes which appear to be identical with those in the woollen section.

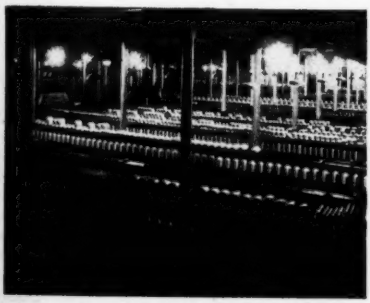

Fig. 1. A modern spinning plant lighted by obsolete drop pendant lighting with conical iron shades.

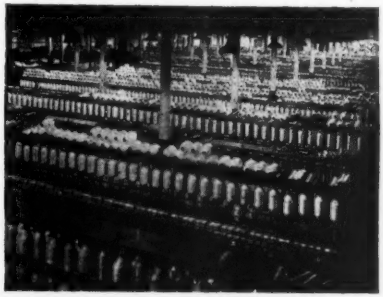

Fig. 2. The same plant illuminated by a general system of standard dispersive lighting.

One fundamental difference between the cotton and woollen sections of the industry worthy of note is that the value of the finished cotton product is very much less per yard than the woollen, and consequently the majority of the finer inspection processes are eliminated. Thus it is uncommon to find perching carried out to any great extent in the majority of mills. Furthermore, owing to the increasing foreign and overseas competition in the production of cotton cloth, manufacturing costs have to be assessed in tenths or even hundredths of a penny per pound, and consequently any increase in overheads, even if producing increased output, is not necessarily welcomed by the management. This has undoubtedly been one of the main factors in hindering lighting development in the Lancashire area, parti-

cularly in those sections where only coarse or medium cloths are made.

The machinery employed for the various processes is on the whole smaller, not so tall or bulky as for a similar woollen process, which leads to a much more common use of multi-story buildings. Weaving sheds and card room extensions are general exceptions where there is characteristic roof lighting. Otherwise natural lighting, where it exists, is from side windows. A mule spinning room, for example, would have mules running the full width of the room up to 130 feet wide, the windows being normally arranged in each of the side walls at points between the mules.

The industry is grouped into several sections which are quite independent, and a particular mill will only carry out certain processes. Thus one finds the spinning sections grouped around Oldham and Bolton and the weaving sections around Blackburn and Burnley. Then again, these sections may well be subdivided into groups dealing with the coarse, medium, and finer sections of the trade.

A typical flow chart of the Spinning and Weaving Sections is given in Fig. 3 below.

Before dealing with individual processes it is advisable to note the fairly standard arrangement of the rooms in the spinning and manufacturing sections of the industry, briefly detailed below:—

1. *Cotton Room.*—Includes bale stores, bale breakers, which, however, may be in separate rooms, and arrangements for mixing if the firm has stack mixing, although this is usually in the fine end of the trade.

2. *Blowing Room.*—Houses opening machinery and scutchers.

3. *Cards Room or Rooms.*—Include all card room processes, some of which may be in an extension with a shed-type roof.

Cards (lap machines).
Drawframes (combers).
Slubbers, Intermediate, Rovers.—Speedframes—one of which may be omitted in the coarse end of the trade.

4. *Spinning Rooms.*—Spinning may be done either by mules or ring frames, but it is unusual to have both together in the same room.

5. *Conditioning (Cellar) and Packing Warehouses.*—This is usually a packing warehouse if the yarn is being sold as cap or ring tube, and generally of basement or sub-basement type.

6. *Winding and Warping Room.*—Contains the winders, which may be of various types, and the beam warpers. Alternatively, doubling or twining may be carried out, usually in a separate mill or in a separate room. If only a few frames, they may go into the spinning room.

7. *Sizing, Taping, or Beaming Room.*

8. *Weaving Shed.*

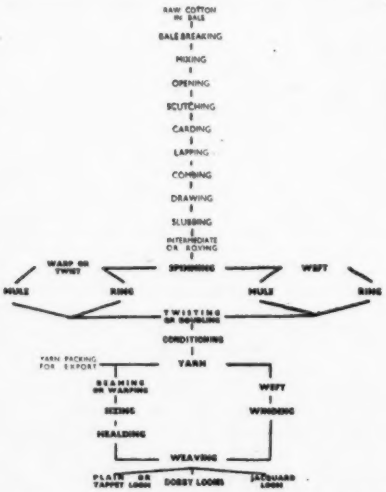

Fig. 3. Typical flow chart (cotton industry). Opening, preparing, spinning and weaving.

Processes

A brief description of the various processes is given as follows:—

Opening and Mixing.—In many mills mixing is done by taking the material from different bales in rotation. In the rare cases where the stack system is retained, a preliminary opening is given to the cotton by the bale breaker. This machine utilises very strong spikes to tear the matted lumps of cotton into smaller pieces. The cotton then passes through the opening machine, which is really a series of machines using spikes and beaters and also pneumatic

actions to extract dust and carry the cotton forward.

Scutching.—Laps or rolled sheets of cotton from the opener are fed four at a time to the scutcher, which again beats the cotton and reforms it in lap form. The object of these preparing machines is to loosen and clean the cotton fibre.

Carding.—This process is similar to scutching, except that it is much finer. As smaller weights of cotton are dealt with the process of fibre separation and extraction of impurities is completed. The form of the cotton is changed from lap to sliver.

Lapping and Combing.—These two processes are confined to high quality Egyptian cotton. The lapping process is usually done in two stages, the card slivers being made into a narrow lap, then doubled and drafted on a ribbon lap machine. The comber combs every fibre and extracts all fibres below a predetermined length.

Drawing.—These frames, by doubling and drafting, make the slivers more uniform in weight per yard, and the fibres much more parallel to each other. Three frames are usually employed.

Slubbing, Intermediate and Roving.—These machines are used to reduce the thickness of the sliver from the draw frames to such a thickness that the spinning machine would be able to produce the fineness of the yarn required. A little twist is given to make the roving sufficiently strong to unwind at the next process. Each of these machines makes packages with conical ends known as "bobbins."

Spinning.—Spinning machines complete the drafting or attenuating of the material and insert twist to give the yarn sufficient strength for its ultimate purpose.

Mule Spinning.—Twists by means of an inclined spindle, drafts by rollers and also by carriage, and winds the yarn on the spindles by the aid of the quadrant motion. It can make a package without tube or bobbin.

Ring Spinning.—Twists by means of vertical spindle, ring and traveller, drafts by rollers only, and winds by the action of traveller, spindle, and ring. It builds a package on tube or bobbin.

Conditioning.—The normal moisture regain of cotton is 8½ per cent. During processing some of this moisture may be lost, and conditioning is the process of reintroducing moisture into the yarn so that it should contain the equivalent of 8½ per cent. regain.

Winding.—Spun yarn from mule of ring frames is wound in the form of bobbins, cheeses, or cones as a preparatory process for yarn intended for warping, doubling, gassing and other processes.

Beaming or Warping.—Warping is the name of the process where a large number of ends of guaranteed length are wound side by side. There are several methods, one of these being beaming or beam warping. In this operation 300 to 600 ends of yarn up to 20,000 yards in length are wound side by side on a beam.

Slasher Sizing.—About six to ten beam warps are placed behind the machine, and up to 5,000 ends are drawn in the form of a sheet through a size mixture, dried quickly, and wound on a weaver's beam.

Healding or Drawing-in.—The ends on the weaver's beam before being taken to the loom have to be drawn through the healds and reeds.

Weaving.—The process of producing cloth by the intertwining of two series of threads, one at right angles to the other, on machines known as looms.

Lighting Requirements

As with other sections of the textile industry, there are many processes which are almost entirely automatic. In almost all cases lighting approximating to daylight characteristics would be preferable, but it is equally true that, until such times as initial costs can be reduced considerably, it seems that there is unfortunately little, if any, chance of widespread adoption of fluorescent lighting. With the introduction of automatic stopping devices, conditions have been produced in many sections of the industry which call for seeing conditions of a very low order. In these cases all that is required of the lighting is to ensure safety and provide cheerful conditions. Processes falling within this category have been shown in the flow chart in black and should be included in the 6 to 10 ft.c. range. These values can best be attained by a general overhead

system of lighting planned to give even distribution throughout the area affected.

There are, however, other processes with pitfalls for the unwary illuminating engineer. Bulky machinery, high-speed operations, vibrating threads all cause their own peculiar troubles, whilst contrast and shadows play an all important part necessitating careful siting of lighting points. It is interesting to note the recent comments of a head of a textile department:—

"Manufacturers are more concerned in finding out the minimum amount of light that can be used rather than the necessary amount for good work."

Another comment recently received stresses the point referred to above:

"Lighting contractors do not pay sufficient attention to the siting of light sources, with the result that heavy shadows are thrown on the work."

The same source emphasised the necessity for the elimination of glare.

The remaining processes must be treated with greater care, as other problems occur besides that of lighting levels. At the moment, however, only levels of illumination will be discussed, leaving details until a later section. These values are those actually on the operation, which may be on any plane.

Spinning and Weaving

(a) Processes calling for medium visual perception (10 to 15 ft.c. range).

Slashing and dressing.
Fancy doubling.
Twisting.
Mule and frame spinning.
Winding
Vertical spindle winding.
Packing.
Weaving (grey cloth).
Inspection (grey cloth) where no mending.

(b) Processes calling for prolonged visual perception (15 to 25 ft.c.).

Warping.
Weaving (light colours).
Mending.

(c) Processes calling for severe visual perception (25 to 50 ft.c. range).

Weaving (dark colours).
Perching.

Cotton Bale Breaking, Opening, and Scutching

Cotton is usually received from various sources, i.e., Egypt, America, in the form of bales which include a good deal of pod and other extraneous substances which need to be removed from the fibre before processing can take place. It is also necessary, in order to secure certain quality cloths, to mix the contents of bales. In these operations the work is rough and a general dispersive system of lighting will generally be found most economical and effective. It is usual to avoid mounting the fittings directly over the machinery in order to avoid the possibility of foreign matter falling into and damaging the machines. Furthermore, as a considerable amount of cotton dust is present a clear glass visor is to be recommended both for maintenance and as a safeguard against fire and explosion.

Fig. 4. A large scutching plant with good general overhead lighting.

Card Rooms

Cotton card rooms differ from those in the woollen industry mainly because the machines are not so high or bulky. Although the processes are mainly automatic there is still need for general illumination on account of the relatively high speed of machinery, together with the necessity for replenishment of laps and the removal of filled sliver cans. Care should be taken to avoid shadows in

the narrow gangways between cards. Reflectors mounted over the gangways will tend to reduce shadows to a minimum.

It is usual for other processes to be carried out close to carding, such as

Fig. 5. Cotton carding plant with lighting fittings mounted over gangways. Good general illumination is necessary.

lapping and combing, although these are not common processes in the majority of the trade, being confined to the production of very high-class yarns. Lighting should be treated in much the same way as for cards.

Drawing (Doubling and Drafting)

Whilst carried out in the same room, the process does require more light than over cards, for here it is necessary to ensure the the slivers are made more uniform in weight and fibre. The illustration, typical of the doubling process, shows the general arrangement of lighting fittings. It will be seen that the machines are low and good general overhead lighting will be satisfactory.

Slubbers, Intermediate and Roving Frames

These frames, similar to those in woollens, are usually some 6 ft. to 8 ft. high and present problems for the lighting engineer. More than normal care is required to light them properly, for not only are horizontal planes involved but vertical and inclined planes as well. Good illumination is therefore required at

(1) A vertical plane about 1 ft. wide running the whole length of the frame about 2 ft. up from the floor (on the spindles or flyers).
(2) A horizontal or inclined plane about 3 ft. 6 in. from the floor on the rollers.
(3) A vertical or inclined plane 4 ft. to 6 ft. from the floor level running the whole length of the frame (on the creel).

Owing to the height of these frames, surmounted by their creels, it becomes essential that lighting fittings be mounted over each "gate" between frames. Staggering of alternate rows of fittings will do much to light the lower vertical plane and to minimise shadow. As already indicated, all these processes are usually carried out in the card room.

Spinning Room

This process is really a continuation of drafting and twisting, and may be carried out according to requirements either on ring spinning frames or by mules. In ring spinning the same

Fig. 6. Doubling and drafting plant lit by a modern system of evenly distributed lighting.

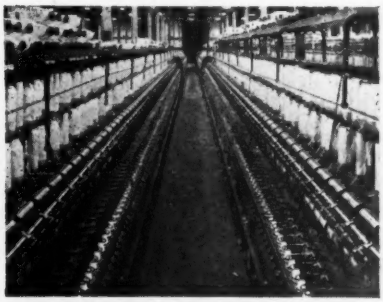

Fig. 7. Ring spinning room. An excellent system of standard dispersive lighting.

conditions apply as in the previous paragraph. The main advantage of ring spinning appears to be in the conservation of floor space.

Mule Spinning

Mule spinning employs a vastly different layout from ring frames and consequently requires entirely different treatment. Mules may easily be up to 130 ft. wide, arranged as shown in the illustration. It is not good practice to mount one row of lighting fittings along the centre of the converging mule carriages, as light is vitally necessary on both the drawing space and the rollers. To secure this at least one row of fittings should be installed above and slightly in front of each row of rollers.

Winding Department

Winding machinery can usually be satisfactorily illuminated by general lighting arranged over each gate. The most difficult types to light are certain pirn winders, where several hundred pirns are concentrated into a comparatively small space mounted row above row. The whole frame is covered by a glass screen, the mounting frame of which will usually provide convenient points of support for local angle type lighting units. Diffusing fittings are recommended in order to minimise glare and soften shadow.

Warping

Warping machinery, although comparatively low built, requires specialised treatment. It may well be that there are up to 500 ends, all coming from different bobbins, mounted on a creel behind the machine. These are "gathered in" and wound evenly on to a beam. In the first place light is required behind the creel, which in plan is in the form of a V. The necessity for this is apparent. Many mills have adopted a practice of suspending a bare lamp in that position, usually at the request of the operator. Whilst a dispersive reflector will be found fairly satisfactory a diffusing fitting will be better, as the operator is constantly watching the bobbins on the creels for stoppages indicating a break. From the creel to the "reed" is a mass of some 500 threads all vibrating and moving forward at a fairly rapid rate. Any breaks must be immediately detected, especially if automatic stoppers are not used. In addition, good lighting is necesary for "joining up." At the front of the machine fittings, preferably of the diffusing type and mounted between ends of adjacent beams, will generally be satisfactory.

Fig. 8. Beam warping. Notice the large number of bobbins on the frames and the threads passing on to the beams. Breaks must be speedily detected.

Slashing or Sizing

In this process several beams are placed behind the machine, and some 5,000 ends forming a loose sheet are drawn over rollers and round on to a weaver's beam. Whilst there is no exacting visual task light is essential under the hood to illuminate the starch box and over the sheet of moving threads. Allowance should be made for a certain amount of steam, which is always present. In some cases lighting is installed under the hood of the machine and fittings suspended over or on either side of the area over which the warp is passing.

Healding or Drawing-In

The lighting for this process calls for careful treatment. The process is often carried out in the same room as weaving and may be done on special frames or on the loom itself. There may easily be twenty-four shafts in the case of "dobby" looms. Each of

these shafts will have a considerable number of heald wires, each with eyes and functioning in a similar way to a needle. Through these eyes must be threaded the correct warp thread.

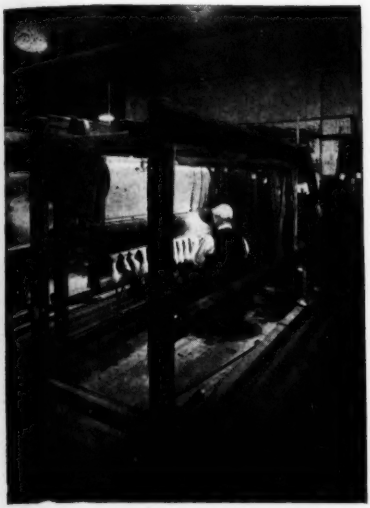

Fig. 9. Healding. A good example of local lighting, the light being entirely shielded from the worker's eyes.

It will be appreciated that with a depth of twenty-four shafts considerable difficulty is experienced in getting the light to penetrate into the masses of wires, and the visual task is both difficult and prolonged. Tests have been made with general lighting alone, but even using fluorescent tubes in various positions the results were unsatisfactory. It would appear, therefore, that the solution can only be found by providing a general illumination of not less than 10 ft.c., with supplementary lighting from small concentrating reflectors which project light on to an area of approximately 1 ft. diameter. This is really the area where the operator requires his light, but due to the presence of an assistant at the rear of the frame care should be taken to ensure that the surface brightness of the concentrating fitting should not exceed two candles per square inch.

Weaving

The process of weaving is undoubtedly the most involved from the lighting engineer's standpoint, for in addition to a multitude of textures, colours, and varied patterns of cloth, several kinds of looms are employed. There are so many variables to consider that a particular scheme must depend upon the assessment of the lighting engineer on the spot, although it is possible to give general guidance.

The type of loom employed depends to a great extent on the class of work, thus the visual task can generally be assessed on this basis. For the purposes of classification it is suggested that three main sections be given as follows:—

Grey cloth	10 to 15 ft.c.
Light colours ..	15 to 25 ft.c.
Dark colours ...	25 to 50 ft.c.

It would, however, be a fallacy to assume that colours or patterns are the only variations, for again the texture is determined by the "counts" of the yarn used. It will be appreciated that the thickness or diameter of the thread will materially affect the task, and it is, therefore, interesting to note a suggested formula for determining the illumination in relation to the counts. Whilst the figures cannot be accepted as conclusive they certainly form a basis for further technical investigation. For this purpose 36s counts are taken as being

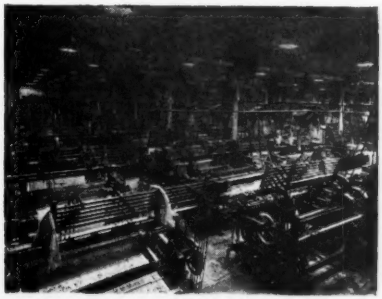

Fig. 10. A well-lighted cotton weaving shed. An even illumination of 14 ft.c. has been secured on these plain cotton beams.

normal. Taking as a basis the mean for grey cloth, namely 12 ft.c., the required illumination will vary as the $\sqrt{\text{counts}}$ and a constant can be determined. Thus the constant becomes for grey cloth:

$$\sqrt{\frac{\text{Basic foot candles}}{\text{normal counts}}} = \frac{12}{\sqrt{36}} = 2$$

Using this rule we can arrive at suitable values which bear a mathematical relationship to the yarn diameter. Thus accepting the difficulty of seeing as being directly proportional to the size of the object, it gives us the basis for all counts, as follows:—

49s counts	$=\sqrt{49} \times 2 = 14$	ft.c.
64s „	$=\sqrt{64} \times 2 = 16$	„
81s „	$=\sqrt{81} \times 2 = 18$	„
100s „	$=\sqrt{100} \times 2 = 20$	„

These figures refer to grey cloth only, that is cloth which has not been dyed or coloured in any way.

Further assumptions must now be made for other conditions, and provided a basis is fixed as 12 ft.c. for 36s counts for grey cloth, values can be predetermined for all conditions.

Thus as a basis:

For light-coloured cloths in blocks use 16 ft.c.

For mixed light colours use 18 ft.c.

For dark colour (self colour) use 18 ft.c.

For pattern work use 20 ft.c.

For warp pattern work use 22 ft.c.

Using the same basis as above, the more complicated cloths could be arranged by adding a further 25 per cent. for increased denting and drafting difficulties.

Thus, say 49s black taking warp pattern work.

Base = 22 for 36s counts.

$$\therefore \text{ ft.c. required} = \frac{\sqrt{49}}{\sqrt{36}} \times 22 + 25\%$$

$$= 26 \text{ approx.} + 6$$

$$= 32 \text{ ft.c. approx.}$$

Working to these rules will give results which coincide very closely with the general values given for the three sections mentioned at the commencement of this section.

It is perhaps as well to point out here that "36s counts" does not mean 36 threads to the inch or each thread 1-36 in. diameter, a definition will be found under the Glossary dealing with trade terms, although it is a fact that the higher the counts the more are the threads per inch.

The lighting engineer is now faced with the problem of shadows and obstructions, for there are very few mills where point-to-point planning can be carried out on paper. Overhead belting, to say nothing of bulky cards or regulating machinery, prevent the ideal from being attained, and in many cases siting must be done on the spot. The looms themselves often present serious complications, and it is no doubt these difficulties which have caused operatives to desire local pendant lighting in many cases.

Looms

Looms can be classified into three main groups, as follows:—

(a) *Tappett or Plain Looms.*—Looms in which the heald shafts are actuated by a simple tappett motion; usually there are no more than four shafts. They are used for plain fabrics of the simplest kind. Overhead obstruction is negligible and general lighting can usually be employed.

(b) *Dobby Looms.*—Somewhat similar to the above, excepting that a small machine or "dobby" is fitted on the loom. Here the heald shafts may vary in number from 16, which is quite common, to 24, and the loom produces cloth with simple patterns. There is overhead obstruction from the dobby and its frame, and the best results will usually be attained by a system of grouped overhead lighting.

(c) *Jacquard Looms.*—Are used for producing the most elaborate of patterns, and the jacquard itself always presents a considerable obstacle to general lighting. The threads are actuated by a jacquard machine which controls bulky "cards" usually over the weaver's head, at the back, or drawn to one side. The packs of "cards" are very bulky in some sections of the trade,

and great care is necessary in siting the fittings to avoid shadows.

Whilst in practice it is difficult to segregate looms for coloured goods from those manufacturing grey cloth, as it is inevitable that there will be some interchange, it is usual for grey cloth to be separated from dark colours or patterns, although light colours are sometimes woven on the same looms.

General Remarks on Weaving

In both plain and dobby looms it is essential that the light penetrates to those portions of the loom where operations are being performed; thus light may very often be required on a vertical plane.

There is an evident need for adequate lighting on the shuttle boxes where, particularly in the case of pattern weaving, spools of different colours are housed. It is important to enable the operator to detect speedily spools running empty and to replenish them quickly. In the case of automatic looms this may not be so pressing, as the weft shuttles are automatically fed to the loom.

Typical of the lag in lighting development in weaving sheds there are still a considerable number of naked gas burners, and elsewhere bare lamps are suspended almost touching the shuttle boxes. By these means very high values of illumination of the order of 200 ft.c. may have been attained locally, and it is little wonder that attempts to dispense with these local bright spots have been strenuously resisted by the workers. Because of the harmful effects of such lighting on the weavers' eyes a large number of them have to wear glasses.

Good lighting is also needed to enable the weaver to watch for defects in both warp and weft, broken threads of which must be quickly joined. Faulty "pieceing" may easily constitute a cloth fault resulting in an ultimate cutting out of the damaged piece, which is often debited to the weaver and is a loss to production.

Breakages usually occur either in the eye of the heald or between the back of the reed and the front of the heald shafts. This can be readily understood, since in the "dents" the material rubs on a harder surface and wear takes place. Alternatively, a break may occur due to the tension imposed on the warp threads as the heald shafts go up and down to form the "shed," or space in which the shuttle containing the weft flies from end to end of the machine.

Thus lighting should be so planned that the weaver has a clear view

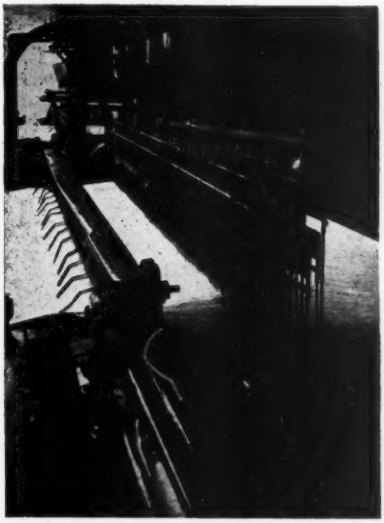

Fig. 11. Details of heald shafts on right and sley on left. Note the layers of threads in the healds.

through the healds. Lighting should also be provided at the back of the loom to give necessary assistance when the heald wires have to be opened if breaks occur there.

There is little doubt that a system of well-diffused general lighting is satisfactory, although it is questionable whether directional lighting is not the most sound solution. Other methods have been tried, such as the use of sight boards under the cloth, or, alternatively, a looking-glass reflector, but the latter has the disadvantage that bad specular reflection can occur where clear lamps are used, as they often are. This is mitigated to a certain extent by locking the mirror at an angle, but again maintenance must be considered.

Systems of well-diffused lighting

have been tried in the woollen industry with some success; production certainly increased and machine efficiciencies, even with automatics, rose to over 90 per cent. Even using a well-planned diffused system, although shadows more greatly reduced, were not eradicated.

Deep shadow was present just behind the sley of the loom where, as already pointed out, breaks may occur. The sley carries the reed which separates and spaces the warp threads. The sley serves also to beat the weft into position. The reeds are supported at the top by the reed cap or handrail which is often the cause of heavy shadow as it moves backward and forward during weaving.

Recent installations of fluorescent tube lighting on looms have been extremely successful. Where it has been possible to mount tubes parallel to the warp they have certainly eliminated reed cap shadows, but in many other cases machine constructional details require them to be mounted at right angles to the warp and just in front of the heald shafts. A suggestion which has been tried with good results is where two looms are positioned face to face, two tubes placed warp ways give excellent results at the fronts, whilst at the back one tube between a pair of looms placed weft ways provides adequate illumination for the picking up of broken ends. Results have shown that where these lamps are used considerable saving in current consumption has resulted, and there are no serious stroboscopic troubles.

Jacquard Looms

Additional difficulties occur with the use of jacquards, particularly where these jacquard machines are transferred from one loom to another as required. All the difficulties of other looms are present, but the presence of cordage extending to overhead harness, or "cards," form with them a complete barrier to the passage of light. These cards and their attendant cordage are constantly moving during loom operations, and whilst the simpler form of jacquard can be dealt with as for other looms, excepting that light must penetrate beneath the cards, the heavier and consequently taller equipments must be carefully treated.

In certain cases, particularly those where there is plenty of headroom, a general system of lighting mounted in the alley way will give good results, but in others it is necessary to supplement such a system by fittings mounted at the front about 3 ft. above the cloth.

Perching

It has already been pointed out that perching is not general throughout the trade. In fact, in any but the finer quality cloths it can almost be said to be non-existent. In the finer end, however, the degree of inspection is generally proportional to the quality of the cloth. Thus where silk or rayon is introduced there might well be elaborate perching arrangements. These may entail passing the material over illuminated panels whose main function is to enable texture defects to be recognised. Panels used for this purpose should be uniformly illuminated and of low surface brightness. In view of the relatively small amount of perching done it is seldom that special locations, such as near north sky windows, are utilised, and generally artificial lighting is used. In certain cases artificially illuminated window panels have been installed, using "daylight" lamps behind diffused glass, in others illuminated troughs, but the most satisfactory is undoubtedly the fluorescent tube with its characteristic low wattage, high efficiency, and almost colour-perfect light.

As shown in the illustration, certain rooms exist where the operation

Fig. 12. Burling and mending room, where corrected visor fittings have been successfully employed.

is performed on horizontal tables with adjustable fittings housing tungsten lamps. In other cases correcting visors are fitted. It should always be remembered that provision has to be made even for blacks, as it is impossible to say what colours may be passed through the process. Adjustable fittings are recommended to compensate for the extreme variations of reflection factors encountered. Generally speaking, there is little mending done, excepting of the finer cloths. Owing to the low value of the finished cloth it is much more common to cut out defective pieces than to accept the relatively high cost of mending.

The Economics of Textile Lighting

In no section of industry can it be more true than in cottons that present lighting conditions are in many cases appalling, and there is still strong opposition from managements to any improvements. This opposition is purely on financial grounds and shows a tendency to subordinate everything to the balance-sheet. Such practice is totally wrong. It is certain that to meet the requirements of the Factory Act relative to minimum values of illumination many mills will need their lighting arrangements entirely reorganised. For example, it is not uncommon to see naked gas-burners in the weaving section, and if for no other reason than fire prevention these should be completely eliminated.

The remarks contained in the paper "Lighting in the Woollen and Worsted Industry" (1) are therefore particularly applicable to cottons, where conditions are even worse. Depression has for so long been advanced as the excuse for all evils that the present time of prosperity, whilst the industry ranks as "essential work," would seem to be opportune for dealing with this long standing trouble.

The author has found many instances where illumination levels are so low that it has been almost impossible to secure a photometer reading at all, and it is, therefore, not surprising that many workers suffer from eye troubles.

Installation Costs

It would not be fair to the industry were one not to point out that the majority of the larger concerns endeavour to instal and keep in efficient operation good lighting systems, so far as economics will permit, but it will be very surprising if considerable numbers of smaller premises are not faced with the need for a completely new installation. As in the wool section, many mills have never attempted to instal planned lighting, the "tackler" has often been the authority who decides where the lighting points should be placed. Thus, even in electrically lit mills, there are low pendant fittings, many without the slightest pretence of light control, and lamps without shades of any description.

Most mills can be efficiently lit by tungsten lamps, excepting for those processes which require lighting approximating to daylight, although there are few processes where A/C discharge systems may not be successfully employed. It is true that in certain operations high-speed vibrating threads may be subject to stroboscopic effect, but it is not necessarily harmful, as discharge lamps have been used with success. Thus when current saving is a major consideration (it is highly probable that in many mills the existing mains and distribution systems will not stand further load) then the higher efficiency of mercury discharge lamps will prove an advantage.

At the present time the use of fluorescent tubes is restricted to factories actually engaged on urgent war work. These lamps will undoubtedly be of vast assistance to the industry, but their full use must await the revoking of the present controls.

This much can be said: that it provides light of a perfect colour for most operations, which factor, coupled with its high efficiency, make it an ideal source for situations where

power consumption must be kept to the minimum.

The Influence of Illumination in Textile Mills.

It is very difficult to attempt to investigate the effect of artificial lighting on the performance of operatives since so many other factors influence production. There are considerations of air temperatures, ventilation, and humidity which, in conjunction with the lighting, affect the environment of the worker. Then in the physical processes of the material such factors as yarn strength and uniformity, sizing, and loom speeds control to a great extent the efficiency of looms. For example, in one particular test, in the first period the time lost through warp or weft breaks was nearly five times as much as in the second; thus it is only possible by taking tests over very lengthy periods to arrive at an average for these factors.

The Industrial Health Research Board has been responsible for several investigations (2), (3) in both the cotton and wool industries to which some reference will be made. The following conclusions can be drawn:—

(1) Poor artificial illumination results in an appreciable drop from the natural lighting production level.

(2) Good artificial illumination results in production being maintained, and in certain cases exceeding that under natural lighting.

In the first case (2) the report states that "In general the output of a cotton weaving shed increases as the proportion of work done under artificial light decreases." This report, published in 1923, found the existing artificial lighting far from good, and it is certain that a modern installation would have given very different results. It suggests that at an opportune time tests should be carried further with modern light sources.

It is well known that the output of a plant falls off towards the end of a working day due, among other causes, to fatigue. If during the last hour or so the illumination is poor, this slowing down is more marked. Similarly, the fall-off during winter months is much more marked than during summer.

Tests carried out since the above have established some valuable data on the economics of intensive lighting of a directional character for shuttle changing looms, weaving a variety of materials. In these tests the only variable was the lighting, and it is thus possible to assess the benefit likely to accrue with better lighting.

As one would expect, it was found that much greater saving was effected where dark materials were involved, owing to the lowered reflection factor, but with both dark and light material the maximum benefit occured at 300 watts per loom, giving an illumination value of 56 ft.c.

At a later date further tests (1) (5) were carried out on the Continent in connection with the silk and artificial silk processes, which are very similar, although finer than those in cottons.

Here figures became available for both warping and weaving, a study of which is extremely interesting. It is evident that production is affected in one of three ways:—

(1) By increasing machine efficiency thus increasing output.

(2) By reduction of thread breakages and increased speed of joining up.

(3) By reduction of number of undetected flaws.

For the purpose of comparison all results have been carefully checked and changed into British equivalents. In each case the value of the original production was known, the original lighting consisting of one 40-watt drop pendant over the creel and a similar lamp over the "gatherer-in" at the beam end. By raising these wattages, and consequently the illumination values, curves were obtained.

Beam Warping

Increased Output.—During tests it was found possible to apportion stoppages for various reasons and to study the effect of improved lighting on the various sections. It was found that thread joining was the most important cause of stoppages either by exhaustion of bobbins, requiring the mounting of new bobbins and consequent joining up, or by yarn break-

ages as well as searching for broken ends. This accounted for about 65 per cent. of the total stoppages of the machine. With better lighting, however, the speed of joining up in-

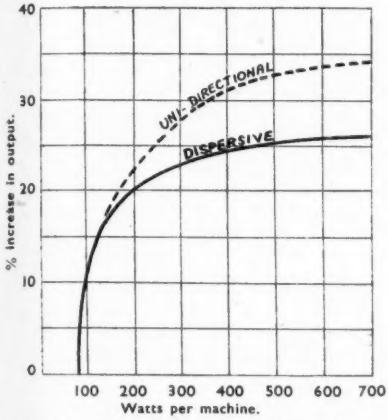

Fig. 13. Silk and artificial silk warping. Increase in output secured by better lighting.

creased by no less than 15 per cent. resulting in a considerable increase in machine efficiency as compared with the original lighting.

In this particular case it seems that unidirectional lighting was preferable to direct lighting. It is a debatable point whether breakage of yarn threads is more readily recognised by the shadow content than by a gap in the surface brightness caused by the missing thread. It is interesting to note that at 500 watts per beam warper, using a dispersive system, the increase in output was approximately 26 per cent., whilst with unidirectional lighting at 500 watts it rose to 33 per cent.

Anlysing these results from an economic standpoint, and knowing the value of the original product, it is possible to find in terms of shillings per year the value of this increased output. This has been done in the final curve given below.

Thus at 500 watts per warper a gross profit of 98s. per annum has been obtained, whilst with unidirectional lighting at 500 watts it has risen to 123s. The remarkable thing is that whilst the curve for dispersive light-

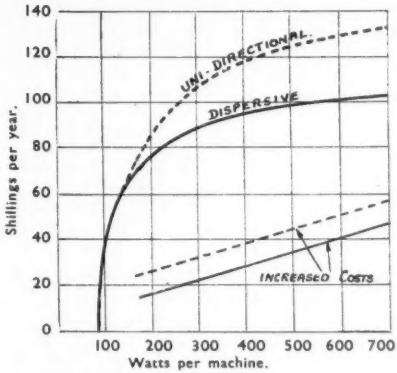

Fig. 14. Silk and artificial silk warping. Net profit from increased output with better lighting.

ing is levelling off at 700 watts that for unidirectional is still rapidly rising as far as it has been taken. To obtain our net profits it is necessary to take from our gross profits such items as increased current costs, lamp replacements and standing charges; this has been done in the two lower curves, the full lines being the dispersive and the dotted the unidirectional lighting. Subtracting the values of the corresponding increased cost curve at any wattage from the increased value of product curve we get our net profits.

Thus:—

At 500 watts per warper (dispersive lighting)—

	£ s.	
Value of the increased output	= 4 18	p.a.
Increased costs	= 1 14	p.a.
	3 4	p.a.

At 500 watts per warper (unidirectional lighting)—

	£ s.	
Value of the increased output	= 6 3	p.a.
Increased costs	= 2 4	p.a.
	3 19	p.a.

In other words, the better lighting paid for itself in both cases approximately three times over.

Weaving

Similar tests (5) were carried out on the weaving side, eight looms

operating on various grades of silk and artificial silk being selected. Lighting systems of both the dispersive and unidirectional types were used and equally interesting results were obtained. The greatest advantage was undoubtedly in improved quality of the product, which considerably reduced menders' time, whilst the increased output is relatively small, being affected by the decreased stoppage time.

The Effect on Output—Increased Production

It is recognised that the cloth value at 1s. 10d. per yard was greatly in excess of that obtainable for cottons, yet the results can be seen to show a distinct improvement with lower-priced material. Thus at 500 watts per loom (dispersive) an increased loom efficiency of 4.8 per cent. was secured, whilst at 500 watts (unidirectional) 5.1 per cent. resulted.

It is interesting to note from the accompanying graph that at the lower values of illumination dispersive lighting showed the best results, and it was not until 475 watts per loom was reached that directional lighting showed an increased advantage.

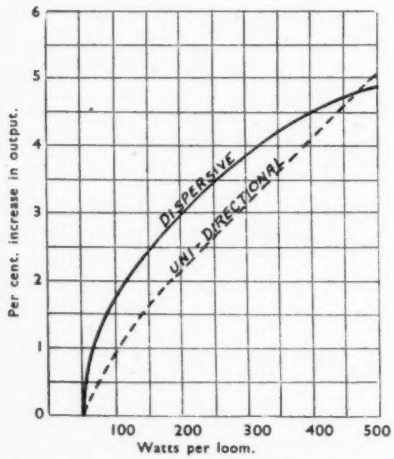

Fig. 15. Silk and artificial silk weaving. Increase in output secured by better lighting.

The Effect on Quality—Decreased Faults.

There is little doubt that the improved lighting assured a very superior product to that produced under bad conditions. Minor defects which would otherwise have passed through into the finished product were detected and remedied in the initial stages. So far as detection of faults was concerned, the unidirectional lighting certainly showed better results than that obtained with the dispersive system as shown in Fig 16. A reduction of approximately 20 per cent. was secured in mending time.

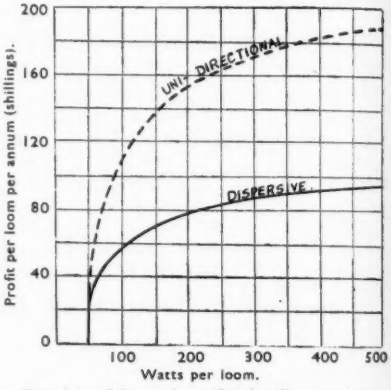

Fig. 16. Silk and artificial silk weaving. Profits from better lighting (improved quality).

Thus at 400 watts per loom—

The gross value of the improved quality with dispersive lighting was £4 12s.

The gross value of improved quality with unidirectional lighting was £9 2s.

Economic Summation of Results

It follows that to find net profits it will be necessary to superimpose the output curve on the quality curve, and from it subtract the increased costs necessary to obtain those results, otherwise a true perspective would

not be given as costs might exceed gross profits. This has been done in Fig. 17 below.

Again the full line shows dispersive

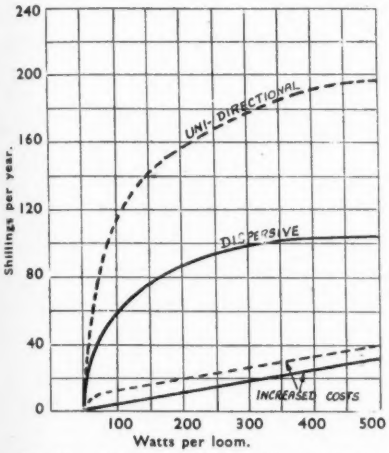

Fig. 17. Silk and artificial silk weaving. Net profits from increased and improved output by better lighting.

lighting results whilst the broken line is that for unidirectional lighting.

Thus at 400 watts per loom (dispersive lighting)

	£	s.	
Value of increased output is	5	2	p.a.
Increased costs	1	6	p.a.
Net profit	3	16	p.a.

At 400 watts per loom (unidirectional lighting)—

	£	s.	
Value of increased output is	9	10	p.a.
Increased costs	1	14	p.a.
Net profit	7	16	p.a.

Thus again improved lighting paid for itself approximately 4 and 5½ times over respectively.

As a further check on these results reference should be made to the paper on Lighting in the Woollen and Worsted Industry (1), where exhaustive tests were conducted on worsteds giving similar results, excepting that it was possible to determine a lighting value at which the maximum benefit was achieved. It should be noted, however, that had other material been used on test there is little doubt that much higher illumination values could have been used with advantage.

From the foregoing statements it can be concluded that the industry would derive considerable benefit by utilising modern systems of lighting. So far as it has been possible to ascertain records in mills which have adopted better standards have confirmed these results.

Maintenance

Modern lighting equipment is designed to present smooth reflecting surfaces on which dust and dirt do not readily collect. The preservation of clean reflecting surfaces is absolutely necessary if the system is to continue satisfactorily. Cleaning of all lamps and fittings at frequent intervals is an economic necessity since the consumer is vitally interested, not so much in the wattage of the lamp used, as in the light received on the work. In textiles, where there is always a considerable amount of dust from the material, no manufacturer can afford to neglect its removal from the lighting fittings. In circumstances where the deposit is heavy use should be made of dust excluding visors. The following illustration shows what happens

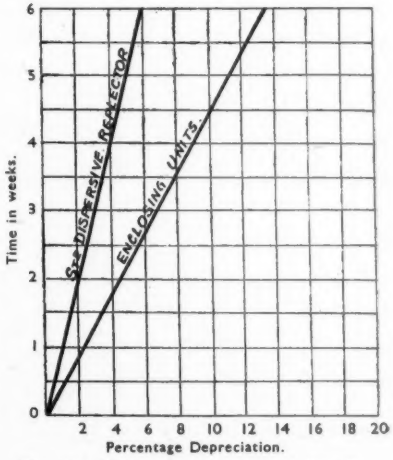

Fig. 18. Maintenance. Depreciation due to accumulation of dust in a well-ventilated area.

when dust is allowed to accumulate in circumstances very different from textile mills. This interior was equipped with extractor fans and was quite dry; worse conditions would be found in cotton mills.

Using standard dispersive reflectors it can be seen that within five weeks depreciation due entirely to dust collection was almost 5 per cent. measured photometrically. Whilst it is true that the dust from cottons is comparatively light in colour, it nevertheless forms a very efficient base for other dust, considerably reducing the light output of the system. The general tendency seems to have been largely influenced by the difficulty of cleaning fittings and lamps when the plant is running, and at other times when labour is not available. It is difficult to give the maximum permissible time which should elapse between systematic cleaning as conditions vary in different sheds, but as a rough guide all fittings should be cleaned at not more than fortnightly intervals. In card rooms or other dusty interiors weekly cleaning would be advantageous. Reference should be made to the related paper on Woollens for a suggested maintenance and cleaning chart, and managements would be well advised to make cleaning of the lighting installations as definite a job as cleaning of looms, etc.

Walls, Windows, and Ceilings

Even assuming that fittings are efficiently cleaned, it must be remembered that walls, windows, and ceilings receive some of the light, and either absorb it or reflect it on to the work. It is important that they should be kept clean, because a good white surface returns 75 to 80 per cent. of the light falling on it. Dark or dirty interiors, on the other hand, absorb light. Where work is carried on under artificial lighting, it will be found useful to use window-blinds, the insides of which are light in colour. These act as reflectors, and will definitely improve the lighting in the immediate vicinity.

Many cotton mills have used coloured wash on the interior of walls, and whilst this may be excellent from a disinfecting or cleanliness point of view, it would be much better still for the lighting engineer if light colours were used.

Lamp Replacement

It is safe to say that the question of proper maintenance has never really been considered by the majority of textile manufacturers. Although lamp failures at varying intervals may easily upset production, it is surprising that more thought has not been given to systematic lamp replacement "Why should I change lamps until they burn out?" is a common question. The reasons are that much time and labour can be saved if only mills will adopt a sound policy of group replacement of lamps. Physical properties of lamp materials determine the life of any lamp, and all manufacturers of repute make to a rigid specification. Thus, even if lamps still burn for a considerable period over the rated "life," the light obtained is likely to be uneconomic. Tungsten lamps should burn for 1,000 hours, mercury discharge for 1,500 hours, and fluorescent tubes for 2,000 hours.

The average mill, as in Yorkshire, still has its handyman who is jack of all trades, and usually knows little or nothing of lighting matters. If the weaver grouses (the term is used advisedly) sufficiently he gets his light where he wants it, and if he does not grouse no one worries.

It is, therefore, suggested that group replacement of lamps should be introduced as a sound policy. Thus if all lamps in any shed are put into circuit, provided they comply with the approximate specification (B.S.S. 161) they should, with very few exceptions, burn out at about the same time. There is no need to labour the point that it is far cheaper to change lamps en bloc after a specified period of use than individually; the fact is obvious, particularly if it can be done when the machinery is stopped.

Experience has proved that though tungsten lamps under normal conditions do fulfil their burning life within very close limits, these conditions seldom exist in textile plants, where vibration is always present, particularly in multi-story premises. It is

suggested, therefore, that on account of this vibration a life of approximately 80 per cent. to 90 per cent. of the normal is likely to occur in tungsten lamps, but in the discharge type, little variation will occur, as they are less liable to vibratory effects.

In conclusion, the author desires to acknowledge the permission of the E.L.M.A. Lighting Service Bureau to publish this paper and wishes to express, particularly to those in the industry who have assisted in collecting information and checking details, his grateful appreciation for services which have made the preparation of this paper possible.

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Glossary of Trade Terms used in the Text of the Paper.

Mules: The frames on which certain yarns are spun. They are low, bulky machines up to 130 ft. long.

Lap machines: Change the cotton rope into layer form known as laps which are usually doubled.

Speedframes: Are frames used to reduce the sliver to a roving and to insert a small amount of twist.

Winders: Machines for winding yarn in the form of bobbins, cheeses or cones.

Warpers: Machines for winding yarn on to the weavers beams or other similar process.

Slivers: Cotton rope as distinct from layers or laps.

Bobbins: A package of cotton yarn with conical ends built on a tube.

Cheeses: Solid cylindrical packages of yarn wound on small diameter tubes.

Cones: Conical packages of yarn wound on paper cones.

Gates: The gangways between two looms facing each other.

Pirns: Weft yarn wound on wooden or paper tubes in the form of a cop and ready for use in the loom shuttle.

Creels: The V-shaped frames on which bobbins are mounted for the yarn to be beamed or warped.

Reed: The part of a beam warper which collects or gathers in a large number of warp threads from the creels for warping on to beams.

Joining up or Pieceing: The process of joining up broken threads.

Ends: The term applied to warp threads in cotton weaving. Thus 500 ends means 500 threads.

Picks: The term applied to weft threads.

Warp or Twist: The yarn usually mounted for weaving purposes on beams.

Weft: Is the yarn traversing through the cloth and intersecting the warp at right angles, and is used on pirns or cops in shuttles.

Counts: The number of hanks of yarn in one pound of the yarn being considered. Indirectly it is the measure of the diameter but differs in cottons, woollens, and worsteds. In cottons 36s counts approximates 156 to the inch, whilst in woollens it is about 80 to the inch and in worsteds it is about 129 to the inch.

Shuttles: The carrier into which pirns or cops of weft thread are placed.

Dents: Each space in a reed is known as a dent.

Healds: The wires mounted in the heald frames or shafts through which the warp thread is threaded.

Reeds: The wires through the "dents" of which the warp is threaded in the sley or going part, and which serve to push the weft forward to form the cloth.

Shed (warp): The opening produced in the warp threads by the operation of heald shafts through which the weft shuttle traverses to form the intersection of the cloth.

Going part or *sley*: The part of a loom which traverses backwards and forwards to beat up the pick of the weft into the cloth.

Cards: The controlling mechanism of a jacquard loom. The cards have the design of the cloth punched through them in the form of a series of peg holes which in turn engage the pegs. These in turn control the operation of the heald shafts.

DISCUSSION

The PRESIDENT (Mr. R. O. Ackerley), after complimenting Mr. Howell upon the very great deal of pioneer work which must have been necessary in order to construct the paper, said that in the past the Society had had presented to it very few papers of its kind, in which a close study was made of the requirements of a particular industry. The textile industry was difficult of understanding to those not directly concerned with it, particularly bearing in mind the difficulties of the nomenclature applying to it; sometimes two adjacent mills used different names for the same process. The glossary of trade terms, which was added to the paper, was useful; and the photographs which had been shown represented a very interesting pictorial review of the processes in the textile industry. One's only regret was that the pictures were not in the form of a cinema film, which could be slowed down to facilitate one's understanding of the various operations.

Mr. H. C. WESTON, congratulating Mr. Howell on an extremely interesting and practical paper, said there were many difficulties peculiar to the cotton industry, and they were very real and obstinate difficulties. For example, the artificial lighting of the drawing-in process and of Jacquard looms had presented a great deal of difficulty for many years, and a wholly satisfactory solution had yet to come.

The photographs shown by Mr. Howell to illustrate the lighting of the various processes in cotton mills were very impressive; in his recollection of the cotton industry twenty years ago, nowhere was there any artificial lighting at that time to compare with the results achieved to-day. It was very pleasing to note that, at any rate in some mills, a very substantial improvement had been effected. In 1923 his colleague, Dr. Wyatt, had shown that the illumination on the looms at that time was only just a trifle more than 1 ft.c. To-day, that appeared to be astonishingly low; but still more astonishing was the fact that the extraordinarily poor lighting had resulted in a reduction of output of only about 5 per cent., due to the fact that the process was so very highly mechanised. It was not really fair, however, to accept that figure as an indication of the effect of bad lighting, because, when regarded in the proper way, it meant that the personal efficiency of the weaver was reduced by something like 25 per cent. Although the effect on the efficiency of the weaver was quite considerable, it was not reflected very greatly in output, owing to the almost entirely automatic nature of the process, at any rate when plain cloth was woven.

A statement in the paper which had left him a little puzzled was that, in the woollen industry, the yarn was much coarser than that in the cotton industry, and in consequence the task involved might be less exacting in the cotton industry than in the woollen industry. Asking Mr. Howell to explain that, he said it seemed at first sight that, owing to the fact that the cotton industry was concerned with a finer thread than the woollen industry, the cotton industry might need the better lighting.

Commenting on the formula put forward in the paper for deciding upon the illumination required according to the counts used, Mr. Weston said that it represented perhaps as good a practical rule as was likely to be found. But he did not think the diameter of the thread really gave the effective visual size, because, except when viewed end on there would be another dimension coming into the retinal image; that would be the length of the thread which, as a component of the image at the fovea, might be regarded as constant. Thus, if the effective visual angle could be regarded as proportional to the square root of the area of the image, it would also be proportional to the square root of the thread diameter. That meant that, whereas Mr. Howell proposed to vary the illumination inversely as the diameter of the thread, in effect he was varying it inversely as the square of the effective visual angle. In that connection, Mr. Weston recalled a suggestion he had made in a recent paper, that within certain limits of visual angle the illumination ought to vary inversely as the cube of the angle. But, he said, since the sizes with which Mr. Howell was concerned did not fall within those limits, he did not think there was any conflict between the two methods; and Mr. Howell's proposed rule had the merit of simplicity.

However, the choice of the basic value must depend on the average viewing distance, and he presumed that Mr. Howell had taken that into account. But he wondered whether the basic value adopted by Mr. Howell was rather on the high side. In view of the very close control of costs which was necessary in the cotton industry, and of the fact that, normally, not a great deal of work had to be done in artificial light, Mr. Weston suggested that the basic value might be placed a little lower. It was important that it should be checked carefully, and he invited Mr. Howell's comments on

the suggestion that it might be taken at 8 instead of 12 ft.c. for 36s. counts.

On the other hand, the proposed increase of the basic value by 50 per cent. when dealing with a dark yarn seemed to be too small an increase. Thus, he was really suggesting a decrease in the values for grey cloth and a relative increase for colours.

Dealing with one or two minor points, Mr. Weston recalled the reference in the paper to the three ways in which lighting could affect production. It seemed to him that the first way, i.e., by increasing machine efficiency, was entirely dependent on the second, since the machine efficiency or running time was not directly affected by lighting, though it depended on the time required to mend thread breakages.

Finally, he said he was puzzled as to why—as shown by one of Mr. Howell's illustrations—the directional lighting was advantageous at a certain wattage, whereas below that wattage the dispersive type of lighting appeared to be better.

Mr. ALAN OWEN, as a member of the I.E.S. who lived in the area of the Lancashire cotton industry, paid a special tribute to Mr. Howell for the thoroughness with which he had prepared the paper. Mr. Howell, he said, had consulted everybody who was anybody in that industry, and had checked all the details. Recalling the Manchester meeting at which the paper had been read, he said that, although it was held at 2.30 p.m., more than eighty people had attended, and it was pleasing to know that the cotton mill managers and engineers who had attended had taken full advantage of the paper. The demand for it had been such that he believed it would be regarded as a text book for the lighting of cotton mills, together with the I.E.S. Code, which included the textile lighting values.

The problem of the lighting of the very difficult process of healding was difficult of solution, although he felt that the surface brightness from the concentrating fitting of 2 candles per square inch as a maximum, proposed in the paper, would prove to be as successful as anything yet tried.

At a factory (not a cotton mill) recently he had noticed some girls examining very intricate machines. The point of focus of each girl's vision varied very much indeed; a young girl was holding the parts fairly close to her eyes, whereas older people were holding them very much further away. The ophthalmic experts knew that that distance varied tremendously according to age. For example, if a child could read, it would hold the reading matter only 2 or 3 inches from the eyes; and as it grew older, that distance would increase. In that connection, Mr. Owen recalled a research carried out some years ago in connection with the linking process in the hosiery industry; the operatives were supplied with glasses having a certain fixed focus. The healds had to be seen sometimes through 24 eyes, and therefore, the point of focus appeared to be a crucial matter in that operation. He did not know whether or not the use of those glasses had been a success in the hosiery industry.

Finally, dealing with Mr. Howell's point that in many cases, in the treatment of the wall surfaces, there had been no discrimination in respect of colour, Mr. Owen said that in one mill in Lancashire, where the lighting was very good indeed, the walls and the machines were painted in various colours, and in some cases contrasting colours. He had been told by the manager of the mill that that treatment of the walls and machines had helped greatly, and that the operatives were undoubtedly happier as the result of that treatment.

A cinema film in colour had been shown throughout North and South America, Australia, and New Zealand, dealing with three-dimensional seeing in industry; it dealt with the use of contrasting colours in the painting of machinery.

Mr. C. W. M. PHILLIPS remarked that there seemed still a likelihood of opposition to good lighting for financial and other reasons. He therefore commended to Mr. Howell a further study on the reasons why good lighting in cotton mills was desirable. If the matter were regarded simply from the standpoint of increased production a stage might be reached when production was limited purely by the capacities of the machines. But he (Mr. Phillips) would not be satisfied with the assumption that good lighting was installed only from this point of view. He suggested that during the next few years the principle might become established that it was a duty to install good lighting—not merely a step that was advisable for the economic benefit to be gained.

Mr. W. J. JONES confessed that, when he was a practical lighting engineer, he had always feared the prospect of dealing with lighting installations in the weaving industries. In the first place, he did not understand the language used by the people in those industries—and he was not sure that he did yet, although the " dictionary " of trade terms printed

at the end of Mr. Howell's paper would be of great help. Secondly, the processes in those industries had always appeared to be very complicated, and there was very great difficulty in getting anyone in the textile industries to appreciate the value of good lighting.

Contrasting the almost entirely automatic processes of the textile industries with the process of making or pressing tiles by hand, in connection with which latter the Industrial Fatigue Research Board had done a good deal of work, Mr. Jones commented that they represented two extremes; in the one case the work could be done almost without light at all, whereas in the other so much depended upon seeing. But in both cases there was a fundamentally important point to note, i.e., that good lighting did assist production. He would not go so far as Mr. Phillips and claim that we should think in terms of better lighting merely for its own sake; the economics of the situation should also be considered and advantage should be taken of the results of the investigations that had been made. Not enough had been made of the tremendous amount of work of that nature which had been done during the last twenty years by Mr. Weston and the Industrial Fatigue Research Board.

Commenting on the work of Goldstern and Putnoky, mentioned in Mr. Howell's paper, he said that when he had first seen the results of that work some years ago he had been so much impressed by the nature of the investigations and the manner in which they had been carried out that he had been most anxious that similar work should be started in this country. Mr. Weston would recall the endeavours that had been made over a number of years to get that work done, and it was because of Mr. Weston's detailed work that substantial English records were made available, of a technical character, related to the improvement of the quality of production.

Emphasising Mr. Howell's remarks concerning the group replacement of lamps, Mr. Jones said he was quite convinced that in post-war days the study of that problem would well repay all lighting engineers; not only was it important in industrial establishments but he believed it would become a dominant consideration also in connection with street lighting problems. He was very glad that Mr. Howell had again drawn attention to it.

Finally, he urged that, when dealing with lighting problems, it was necessary not only to devote attention to considerations of economics, prevention of accidents, production, and so on but also to bear in mind that good lighting created a very cheering atmosphere and was well worth while from that point of view.

Dr. H. BUCKLEY, discussing the diagrams showing the effect of good lighting on output and profits, pointed out that the datum value in all cases was 50 watts per machine, and the graphs had risen rather rapidly to 60 or 70 watts. He had been rather puzzled as to why the datum was 50 watts; if the datum had been 70 watts the profit would have appeared less and the increments less. He asked whether the value of 50 watts corresponded to what was actually used on the machines, because it seemed to him that the average working condition should be the basis. Perhaps he had missed that in reading the paper.

Commending Mr. Owen's suggestion to utilise colour to a greater extent than was usual in cotton mills, Dr. Buckley said that illumination of a high value and of the right order of magnitude was provided, but when it was installed and photographed it very often tended to look like the mere mechanical production of light; it had not much "personality," and for that reason he was glad that he did not have to work in a cotton mill. After all, in our homes we did not merely provide raw light but introduced what was called the "feminine touch," which gave better appearance without detracting from efficiency. If the machinery and walls in a mill or factory were painted and decorated in certain colours it would probably have a beneficial psychological effect. This would be in addition to improved mechanical efficiency resulting from the provision of the intensity and quality of lighting necessary for the carrying out of the particular process.

Mr. J. S. Dow, after congratulating Mr. Howell on his remarkable series of illustrations, drew attention to a reference in the paper to dark material requiring approximately double the illumination required for light material. That, he said, did not appear to square up with Mr. Weston's method of analysis. In dealing with very light and very dark materials, the one having the reflective power of perhaps only 5 per cent. of the other, an increase of more than twice the illumination would surely be needed.

He would like to know more about the

comparison of the unidirectional and the general lighting, for he did not even yet follow which method was the better of the two, or, indeed, whether it could really be said that one method had established itself as being better than the other.

Recalling Mr. Howell's references to the fluff which rose into the atmosphere from cotton materials, Mr. Dow wondered whether, in addiiton to its effect in depreciating so greatly the efficiency of the fittings it also reduced the illumination appreciably by reason of absorption in the atmosphere. It had been discovered lately that there was a good deal of absorption of light by the atmosphere in some industrial establishments.

He could not help feeling that, where all the lighting was directed from above, there must be a considerable reduction of lighting intensity at successive levels from the level of the light sources to the floor, and he wondered whether anything could be done from below to even up the lighting values. In that connection he said he believed that more importance was now being attached to the provision of a light coloured floor, which reflected a useful amount of light upwards. Was it possible that a white floor might effect an improvement in illumination for textile processes, particularly in rooms where complicated machinery, such as that used in the cotton industry, had to be operated.

When visiting cotton mills, some of them lighted by gaseous discharge lamps, he had been impressed by the curious fact that although one frequently noticed stroboscopic effects on pulleys and things of that nature, they did not seem apparent on the bobbins, even where discharge lamps of the ordinary variety were used. He asked whether that difference was due to the high speed at which the bobbins operated.

That reference to stroboscopic effects reminded him of a wonderful lecture given to the Society many years ago by Dr. J. F. Crowley, who, using intermittent light from a neon tube, had timed the pulses of those neon lamps so that the speed of operation of a sewing machine appeared to be slowed down so that one could almost watch every individual movement of the parts. One would have thought that there were opportunities for the application of that kind of slowing-down process in connection with textile machines when detecting faults. He wondered whether intermittent neon light was ever used to any extent for that purpose.

The PRESIDENT, commenting on Mr. Howell's reference to eye strain and his statement that a large number of people employed in the textile industry wore glasses, asked whether there was any practical evidence to support his statement that the glare on the healds was responsible for eye strain. Anticipating the probable reply that such evidence was difficult to obtain at the moment, the President asked whether Mr. Howell could devise any method of watching processes in some of the better-lit mills in order to find out whether, in the course of years, there was any apparent decrease in the proportion of people who had to wear glasses. Attempts had been made to obtain practical evidence on that matter for a very long time.

Emphasising the point he had made at the beginning of the discussion with regard to the value of papers giving the results of the study of the lighting requirements of particular industries, the President commended to the Papers Committee of the Society the suggestion that it should try to arrange for the presentation of one paper of that kind each year. Investigations were being made already in the north of Enland, in the garment industry, the steel industry, and others, and it was part of the Society's policy to encourage such investigation.

Mr. J. W. HOWELL, in thanking the members for their kind reception of his paper, said he had tried to make it as comprehensive as possible.

Replying to Mr. Weston's question concerning the coarseness of the woollen yarn relative to cotton yarn, as a result of which the conditions in the cotton industry were less exacting than those in the woollen industry, he pointed out that cotton yarn had a relatively smooth thread, whereas in the woollen and worsted industry the thread would vary in nature; consequently, the task of watching the thread, travelling at a high speed, was more difficult in the woollen and worsted industry than in the cotton industry, for the cotton thread had clear-cut edges.

With regard to his suggested lighting values, he said that in the first place they were fixed as the result of actual tests rather than upon a predetermined formula; the value of 12 ft.c., which he had given as a basis, was actually fixed after tests made in various technical departments of the textile industry in the

Lancashire area. That might not be a very scientific method, but it was a method which Lancashire cotton men understood. They were not so much concerned with what scientists told them as they were with the value to be derived from their installations.

Dealing with the comments made on the graphs which illustrated the benefits of good lighting of both the dispersive and the unidirectional types, he said that in one case the tests were commenced at the 50-watt basis. The graphs showed the results of the improved conditions; they did not show the results obtained in series, starting from nothing or from any particular wattage, but were plotted on five predetermined points.

The PRESIDENT asked what was the average value used at present in the cotton industry.

Mr. HOWELL replied that on looms the average value was, roughly, of the order of about 120 watts per loom.

The suggestion that machines and walls should be painted in various colours was extremely interesting; but the financial aspect must be borne in mind. He was quite sure that unless this colouring could be proved to pay for itself, by way of increased output, the managements in the cotton industries in the north would be averse to the application of various colours to machines.

The lighting of looms from underneath had been tried, but it had achieved little success, owing to the very high cost of maintenance of lighting installations underneath the weave, it being practically impossible to keep them clean. When machinery had to be operated, and where oil and other such commodities were present, the difficulties of keeping the floors clean would be appreciated.

With regard to eye strain, some little time before the war the weavers' trade unions in the northern areas had complained to the Government Departments concerned on the fact that many of the operatives had had to wear glasses. Unfortunately, there were no statistics available to show that the installation of improved lighting had reduced the necessity for wearing glasses, and he imagined that a considerable time must elapse before we could collect the information from which to compile such statistics.

Additions to List of Members.

The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

SUSTAINING MEMBERS:—

Rowlands Electrical Accessories, Ltd. .....157, Hockley Hill, BIRMINGHAM, 18.
Representative: K. Scott-Adie.

CORPORATE MEMBERS:—

Archbold, F. N. .....1367, High Road, Whetstone, LONDON, N.20.
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Batterby, G. S.....“The Limes,” Kings Newton, Melbourne, DERBY.
Beacall, R. P. .....69, Elgin Avenue, Harrow, MIDDLESEX.
Bennett H. G.....Montvue, Castleton Road, Hathersage, nr. SHEFFIELD.
Broadbent, M. E.....Hillside House, Kirkheaton, nr. HUDDERSFIELD.
Brockies, S. C. .....77, Ritherdon Road, Balham, LONDON, S.W.17.
Brown, E. .....2, Disley Avenue, West Didsbury, MANCHESTER.
Charlton, J. G. .....184, Westwick Road, SHEFFIELD, 8.
Dickinson, S. M. .....Gayhurst, Upton Lane, Upton, CHESTER.
Dixon, G. .....Holophane, Ltd., Elverton St., Vincent Sq., LONDON, S.W.1.
Ellis, J. W. .....18, Queen's Road, Watford, HERTS.
Fordham, H. F. .....145, Gatley Road, Gatley, CHESHIRE.
Halliwell, J. R. ..... 4, Patch Lane, Bramhall, CHESHIRE.

ADDITIONS TO LIST OF MEMBERS

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Jewitt, E. .....93, Palmerston Street, DERBY.
Margolis, W.....20, Trent Boulevard, West Bridgford, NOTTINGHAM.
Mutlow, F. .....105, The Drive, Roundhay, LEEDS, 8.
Nutton, J. H. .....East Hull Gas Co., St. Mark Street, HULL.
Ostick, J. T. .....20, Tamworth Road, Long Eaton, NOTTS.
Prentice, F. S. .....39, Castle Street, DERBY.
Sawyer, G. D. .....c/o Midland Bank, Ltd., 52, Oxford Street, LONDON, W.1.
Slater, N. C.....39, Ribblesdale Road, Sherwood, NOTTINGHAM.
Spencer, S. K. .....26, Carr Manor Grove, Chapel Allerton, LEEDS, 7.
Stonham, B. .....East Hull Gas Co., St. Mark Street, HULL.
Taylor, W. H. .....8, Bold Lane, DERBY.
Thomas, H. N. .....27, Chaucer Road, Bath, SOMERSET.
Thorneycroft, J. E. ...Prestbury, Johns Road, Radcliffe-on-Trent, NOTTS.
Tucker, D. K. .....1, Lakeside Road, Palmers Green, LONDON, N.13.
Walters, W. .....Austin Walters and Son, Ayres Road, Old Trafford, MANCHESTER, 16.
Wedge, G. A. .....60, Hervey Close, LONDON, N.3.
Winstanley, F. .....The General Electric Co., Ltd., Magnet House, Kingsway, LONDON, W.C.2.

TRANSFER TO CORPORATE MEMBERS:—

Perkins, W. F. .....379, Hucknall Road, Sherwood, NOTTINGHAM.

ASSOCIATES:—

Mitchell, R. F. .....7, Mansfield Road, Heanor, NOTTS.
Porter, E. W. .....33, Carlton Road, DERBY.
Scargill, G. .....27, Broadgate Road, MIDDLESBROUGH.
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Macleod, D. .....1, Edward Road, Quinton, BIRMINGHAM, 32.
Merritt, P. G. .....27, St. Cloud Road, West Norwood, LONDON, S.E.27.
Purchase, P. T. W. ...159, Hook Rise, Tolworth, Surbiton, Surrey.

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With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form :—" Trans. Illum. Eng. Soc. (London)."

Papers Read Before Centres and Groups

ELECTRIC DISCHARGE LAMPS AND FLUORESCENT TUBES, by E. L. RANDALL (*Member*).

Summary of a paper read before the Nottingham Centre (Midland Area) on March 26, 1943.

The author commenced his paper with a brief review of the development of incandescent filament lamps, drawing attention to the inherent limitations of sources of light based on incandescence. Early forms of discharge lamps, whilst more efficient, were complex and inconvenient in use and the pronounced colour of the light was a drawback.

Modern sodium and mercury vapour lamps were next described. It was shown how the application of fluorescent powder made colour correction possible. This led to a description of the latest 80-watt fluorescent tube, in which the ultra-violet component was accentuated, this radiation being transformed into visible light by action on a fluorescent coating on the tube. In spite of its apparent simplicity the evolution of this lamp had involved an immense amount of research. Many fluorescent powders, yielding light of varying colour characteristics, had been produced. A mixture of powders enabled a light closely resembling that from the north sky to be produced. The persistence of the glow after activation had ceased (phosphorescence) was a definite advantage, as it diminished the stroboscopic effect. The application of the fluorescent coating required care; it must be thick enough to convert all the ultra violet radiation into visible light; but yet sufficiently thin not to obstruct the passage of light emitted by the inner layer of powder closest to the discharge.

Mr. Randall also reviewed the performance in practice of fluorescent lamps, pointing out that the main factor responsible for limiting the life was the condition of the electron-emissive surfaces of earths used to coat the electrodes. He traced the diminution in light output, rapid during the first hundred hours but slower afterwards. This fall is apparently due to the production of a film on the surface of the fluorescent powder.

The paper was illustrated by numerous experiments. The appearance of coloured surfaces viewed by the light of different forms of discharge lamps and the reactions of various minerals to ultra-violet radiation were demonstrated. In conclusion a fluorescent 4-watt tube of very small dimensions, developed in the U.S.A. for special purposes, was exhibited.

APPLICATIONS OF LOW PRESSURE FLUORESCENT LAMPS, by W. R. STEVENS (*Fellow*).

Summary of a paper read before the Leeds Centre (North Midland Area) on April 19, 1943.

On April 19 Mr. W. R. Stevens read a paper dealing with the applications of low-pressure fluorescent lamps, with particular reference to the 5-ft. mains voltage type. The paper did not deal with the development or characteristics of the fluorescent lamp itself, but rather with the design of fittings for use with this type of lamp. The development of the diffusing trough type of fitting was described and shown to be the natural outcome of wartime restrictions and requirements. The results of some experiments to determine the optimum sizes of diffusing fittings were given by the author, who went on to discuss multi-lamp fittings briefly. The specular type of reflector was then dealt with and the limitations on design imposed by the size and brightness of the source referred to. Mr. Stevens concluded by showing some excellent illustrations of typical installations in which 5-ft. fluorescent lamps are employed in factories, etc.

The discussion was opened by Mr. W. F. Pogson, and other members who took part were Messrs. J. H. Mollan, C. Dale, J. H. Jackson, S. Hepworth, S. Addison, J. W. Howell, and T. H. Ingram. Mr. Stevens replied to all the points raised by the various speakers, and the meeting concluded with a hearty vote of thanks to the author, proposed by the chairman and carried unanimously.